Question: *We have one additional question arising out of our discussion today. It is somewhat general. Suppose that the tree-diagram values of α, β and γ are just the standard model values and that the real interesting physics is in the penguin diagrams (this may be what one will conclude from the B factories by the time you run. Note that in Jeff Richman's talk he has a plot of what would be beta in the standard model measured from the b to s penguin and it differs from expectations if you average many modes). What would BTeV be able to add (for example can you measure the weak phases of the b to s and b to d penguins?).*

We don't agree with the premise you stated below that says the B factories will have measurements of α, β and γ by the time of BTeV. There clearly will be some limited information on α and γ but it will not be definitive, I don't think either one will be measured below 10 degrees. (And you didn't mention χ.) In α for example, we just sent you a note on B→ρρ. One additional point is that the current limit on the Penguin phase is 13 degrees and that gets better as the bound on B→ρ°ρ° improves but only by the square root of the branching ratio, so that will take a lot of data. Of course if a rate is measured then the bound will not improve.

We do agree that measuring the phases in the Penguin modes is important. I have attached the response to your first question in the original review. On page 24 and 27 we discuss our ability to measure the phases in B→φ K_s and B→φ K^-. They are excellent, far exceeding the B factories. Of course we can do other modes. Another example that will be very interesting is B_s→φη$^{(')}$, a mode unique to BTeV. Here, we are measuring the b→sss Penguin phase relative to χ rather than β.

The above example takes care of b→s penguins. The case of b→d penguins is rather more difficult in purely hadronic modes. We can do CP violation in the exclusive modes B^o→ργ and B^-→ρ$^-$γ versus B^+→ρ$^+$γ, B_s→K*γ, but since the K*→ K^-π$^+$ is a flavor tag the mixing part would be missing, which is good. Also B^+→ π$^+$ ℓ^+ ℓ^- versus B^- → π$^-$$\ell^+$ ℓ^-. There are analogous cases for the b→s Penguins as well, B_s→φγ being an excellent example.

I would like to add to our answer to your second question. There are it turns out three modes which are unique hadronic b→d penguins that cannot also come from tree level diagrams and are CP eigenstates. The modes occur when an s-quark anti-s quark pair is popped from the vacuum. Thus B^o →K_s K_s and B_s →φ K_s fit this category. In addition the charged mode B^+→ K_s K^+ is also pure b→d penguin.

All three of these modes can be used in BTeV to measure the b→d penguin phase should the branching ratios be large enough. The efficiencies and backgrounds for B_d→φ K_s are given in our answer to question 1. The same would roughly apply to the B_s mode. In the B_d mode we expect about 2000 events in 2 fb^{-1} with a Signal/background of 5.2:1. In the B_s mode we would expect 1/4 just do the fact that B_s production is less than B_d production. The branching ratio, of course, is very interesting as new physics could raise in. Without new physics we expect it would decrease by about a factor of 10, giving roughly 50 events with S/B of 1:2. This is good enough to get the branching ratio in a few years of running. CP violation will take longer.

For $B^+ \to K_s K^+$, we can view our simulation of $B^+ \to K_s \pi^+$. Here we found we were about half as efficient as in $B^o \to J/\psi K_s$, mainly due to the trigger. Thus considering the excellent particle identification, we should be able to measure the branching ratio in this mode if it is Standard Model.

The mode $B^o \to K_s K_s$ will require more study for us to conclude how well we can measure it. We would have to concentrate on events where both K_s were found in the pixel detector in order to measure the B decay vertex. In general 1/2 of the K_s are found in the pixel detector for $B^o \to J/\psi K_s$, so this look very possible, but we wouldn't want to state it before we did the simulation.

In summary, the situation is more hopeful for b->d penguin phases than we thought.